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Effect of Vacuum Time and Steam Blanch Temperature on the Quality of Canned Apple Slices[1, 2]

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Abstract. Slices of Golden Delicious, Stayman, and York Imperial apples were subjected to 3 vacuum periods and 3 subsequent steam blanch treatments in a factorial arrangement prior to canning. Fruits of different harvest maturity and storage ripeness were included in the study.

Firmness of cooled blanched slices was a satisfactory predictor of canned slice firmness as an in-plant procedure. Vacuum treatment was necessary for satisfactory quality of canned slices. Extending vacuum time over 1½ min, except for color development, was not beneficial. Steam blanch temperatures over 212°F were detrimental to firmness, wholeness, sloughing and flavor, but resulted in the best color quality in the canned slices.

A vacuum time of 1½ min followed by a steam blanch of 212°F for 20 sec gave an optimum canned slice drained weight increase of about 10–12% without sacrificing other quality factors. As drained weights increased over 15%, slices became water-logged and soggy. About ½ of the drained weight increase in canned slices should be gained during the vacuum-blanch operation.

Process combinations of 1½ min of vacuum and steam blanch temperatures of 212 or 225°F were optimal for the varieties, maturities and storages used in this study. The York Imperial variety because of its flesh firmness and tissue discoloration can benefit from blanch temperatures slightly higher than 225°F.

INTRODUCTION

Two of the most difficult processing problems facing the canner of apple slices are the removal of intercellular gas and shrinkage of the slices while maintaining high quality. Since the patenting of the Sellars method (2) of removing gases from apple slices, many additional methods and variations thereof have been introduced, along with techniques to shrink the slices. The most popular method has been the use of a vacuum on the slices, followed immediately by a short steam blanch; however, the lengths of exposure to vacuum and to the blanch temperature have varied among packers. A recent study of Shallenberger *et al.* (3) indicated that firmness of canned Rhode Island Greening apple slices increased as blanch temperatures were increased. Varieties grown in the Appalachian area do not seem to react in this manner.

Since the physical and chemical properties of apples vary considerably among varieties, a further investigation was conducted involving combinations of vacuum times and blanch temperatures and their effects on quality and drained weight of the canned apple

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Table 1.—Effect of harvest, storage, vacuum time, and blanch temperature on the shear (lb force) of blanched Golden Delicious, Stayman, and York apple slices.

	Golden Delicious	Stayman	York
Harvest	*lb force*	*lb force*	*lb force*
1st	204.3 a	223.1 a	339.1 b
2nd	201.4 ab	218.4 a	382.6 a
3rd	192.3 b	215.5 a	341.2 b
4th	175.9 c	175.5 b	321.9 c
Storage (% expected storage life)			
0	288.4 a	367.3 a	423.3 a
50	175.9 b	165.1 b	360.2 b
100	116.2 c	92.1 c	246.1 c
Vacuum time (min)			
0	183.9 a	203.1 a	343.0 a
1½	199.9 b	211.7 b	352.3 a
3	198.5 b	213.7 b	350.6 a
5	191.7 ab	204.2 ab	338.8 a
Blanch temperature			
None	371.2 a	394.7 a	567.8 a
212°F	166.6 b	174.1 b	305.3 b
225°F	136.9 c	145.5 c	273.2 c
240°F	99.3 d	118.4 d	238.3 d

slice pack. Effects of fruit maturation and storage on quality were also studied.

Experimental Methods

Three varieties of apples were studied: Golden Delicious and Stayman, grown at the University of Maryland Plant Research Farm, Fairland, Md. and York Imperial obtained from a commercial grower near Hancock, Md. Four different harvests of 25 bushels each were made. The first harvest was very immature, and the third was considered to be optimum. Harvest dates were determined by a combination of shear press values, total acidity, and per cent soluble solids. All fruit was stored in the same refrigerated room at 32°F and at high humidity.

Processing: Apples from each harvest were removed from storage for processing the day after harvesting and at intervals corresponding to 50% and 100% of the expected storage life of the respective varieties (4). Lots of 20 apples selected at random were used for each treatment. Fruit was pared and cored mechanically, trimmed by hand, and placed in a 3% NaCl solution. Apples were then sliced into 14 equal sections, rinsed to remove the salt, and processed as follows:

Table 2.—Correlation coefficients between various factors studied.

Factors	d/f	Variety		
		Golden Delicious	Stayman	York
Shear after blanch vs shear of canned slices	142	.978**	.995**	.816**
Drained weight vs shear of canned slices	190	−.435**	−.344**	−.322**
Shear of canned slices vs organoleptic firmness	190	.833**	.910**	.710**

**Significant at 1% level.

Table 3.—Effect of harvest, storage, vacuum time, and blanch temperature on the drained weight of canned Golden Delicious, Stayman, and York apple slices.

	Varieties		
	Golden Delicious	Stayman	York
Harvest	*Drained weights*[x]	*Drained weights*[x]	*Drained weights*[x]
1st	229.9 a	227.6 a	224.1 b
2nd	226.4 c	224.4 b	222.0 a
3rd	226.6 c	223.9 bc	224.7 b
4th	227.8 b	223.1 c	225.0 b
Storage (% expected storage life)			
0	224.2 a	221.8 a	223.5 a
50	227.2 b	225.4 b	223.2 a
100	231.5 c	227.8 c	225.8 b
Vacuum time (min)			
0	233.2 a	228.7 a	228.0 a
1½	224.4 c	221.2 d	221.0 d
3	225.1 c	223.5 c	222.9 c
5	227.8 b	225.5 b	224.8 b
Blanch temperature			
No Blanch	222.6 a	224.7 b	210.0 a
212°F	221.8 a	219.2 a	219.1 a
225°F	228.0 b	224.5 b	225.6 b
240°F	238.1 c	230.5 c	233.0 c

[x]Fill-in weight 200 g.

1. Raw slices were placed in a blanching basket in an upright retort adapted for use with a vacuum pump.
2. The retort was sealed and slices were subjected to no vacuum or 1½, 3, or 5 min vacuum at 29 inches Hg.
3. The vacuum was broken by direct steam, and the temperature was raised to 212, 225, or 240°F, in 30, 45, and 60 sec respectively. These temperatures were maintained for 20 sec and released. For samples receiving no heating, the vacuum was re-

Table 4.—Effect of vacuum time × blanch temperature interaction on drained weight of canned Golden Delicious, Stayman, and York apple slices.

	Blanch temperature			
Vacuum time (min)	None	212°F	225°F	240°F
		Golden Delicious Drained weights[x]		
0	219.2	227.0	237.4	248.8
1½	222.4	218.8	224.4	231.8
3	222.6	220.2	223.6	234.2
5	226.2	221.2	226.4	237.0
L.S.D. 1% = 4.4				
		Stayman Drained weights[x]		
0	219.8	224.2	232.0	238.8
1½	225.0	216.2	218.4	225.2
3	226.8	218.0	222.0	227.2
5	227.2	218.4	225.4	230.8
L.S.D. 1% = 4.8				
		York Imperial Drained weights[x]		
0	217.8	222.6	233.2	239.2
1½	217.8	215.8	220.4	229.8
3	220.6	217.4	224.4	229.6
5	219.8	220.4	225.6	233.4
L.S.D. 1% = 4.8				

[x]Fill-in weights 200 g.

Table 5.—Effect of harvest, storage, vacuum time, and blanch temperature on shear (lb force) of canned Golden Delicious, Stayman, and York apple slices.

	Golden Delicious	Stayman	York Imperial
Harvest	*lb force*	*lb force*	*lb force*
1st	69.9 a	93.1 a	148.6 ab
2nd	68.6 ab	108.5 b	188.4 c
3rd	67.1 ab	105.9 b	142.3 a
4th	60.9 b	92.4 a	158.6 b
Storage (% expected storage life)			
0	116.9 a	188.9 a	206.1 a
50	52.9 b	70.8 b	158.5 b
100	30.0 c	40.2 c	113.8 c
Vacuum time (min)			
0	51.4 a	85.9 a	151.9 a
1½	71.6 b	103.2 b	161.2 a
3	72.9 b	105.6 b	161.1 a
5	70.6 b	105.2 b	163.6 a
Blanch temperature			
None	58.8 a	87.3 a	160.1 a
212°F	76.2 b	112.8 b	172.0 a
225°F	73.5 b	107.5 b	160.0 a
240°F	58.0 a	92.2 a	145.7 b

leased by opening an overflow valve. In cases having no vacuum, the temperatures were raised to the designated levels and held for the required 20 seconds before releasing.

4. Slices were removed from the retort and canned as follows: 200g of slices, along with 1 oz sugar dissolved in 75 ml of 200°F water, were placed in 5 No. 1 (211 × 400) plain sided cans having F-enamel ends. For non-blanched samples, 150g of slices were used because such slices were quite bulky and did not pack tightly when canned; however, all data are presented on the basis of a 200g fill weight.
5. Cans were sealed and heated for 8 min in boiling water, cooled, and stored at 60° to 65°F.

Laboratory analyses: Cooled 150g samples of each treatment were taken just after the blanch and before canning for determination of shear. Slices were placed in the standard shear cell of a L.E.E.-Kramer shear press, having a 3000 lb ring and stroke speed of 20 sec. All slices were placed perpendicular to the blade (4).

Canned samples were kept in 60–65°F storage at least 1 month prior to analysis. Contents of 2 cans were drained for 2 min on an 8-mesh screen and weighed. Shear of the canned slices were determined as described above for the slices after blanching. Canned slices were evaluated organoleptically for firmness, color, flavor, wholeness, and sloughing by a panel of 5 persons. A 7-point scale was used for firmness as follows: −3 mushy, −2 too soft, −1 slightly too soft, 0 ideal firmness, 1 slightly too firm, 2 too firm, and 3 much too firm. The other 4 factors were evaluated using a 10-point scale with 10, 9, and 8 as fancy, 7, 6, and 5 as extra standard, 4, 3, and 2 as standard, and 1 as substandard.

Table 6.—Effect of harvest, storage, vacuum time, and blanch temperature on color of canned Golden Delicious, Stayman, and York apple slices.

	Golden Delicious	Stayman	York Imperial
Harvest	*Panel Scores*[x]	*Panel Scores*[x]	*Panel Scores*[x]
1st	6.4 a	7.2 a	7.2 a
2nd	7.0 b	7.6 b	7.5 b
3rd	7.4 c	7.5 b	7.7 c
4th	7.5 c	7.4 ab	7.4 b
Storage (% expected storage life)			
0	7.1 a	7.7 a	7.8 a
50	7.2 a	7.3 b	7.3 b
100	7.1 a	7.2 b	7.2 b
Vacuum time (min)			
0	6.1 a	6.3 a	6.9 a
1½	7.5 b	7.6 b	7.5 b
3	7.3 b	7.8 b	7.5 b
5	7.5 b	7.8 b	7.8 c
Blanch temperature			
None	5.0 a	6.1 a	6.0 a
212°F	7.4 b	7.5 b	7.4 b
225°F	7.9 c	7.9 c	8.1 c
240°F	8.2 d	8.1 c	8.2 c

[x]10 point scale with 10 most desirable.

Statistical analysis: The experiment was designed as a factorial problem, and all data were subjected to appropriate statistical analyses. The effects of 4 harvests, 3 storage periods, 4 blanch temperatures, and 4 vacuum times within each variety were evaluated by the analyses of variance (1). The main effect means were separated by Duncan's multiple range test and interaction means by LSD values. Coefficients of correlation between various factors were also determined.

Results and Discussion

Blanched fruit: Firmness measurements were made on slices that were blanched and cooled to room temperature (Table 1). Blanched fruit firmness decreased with increasing maturity, longer storage, and higher blanch temperatures. Blanched slices made from fruit of the second harvest York Imperial were firmer than those from the immature first harvest. This may be due to incomplete development of cell-wall polysaccharides in the more immature fruit. Correlation coefficients between shear of blanched slices and shear of canned slices ranged from +.816 to +.995 (Table 2). These correlation coefficients can be used as an in-plant procedure in conjunction with process variables through multiple regression equations to predict firmness quality of the canned slices.

Canned fruit: The drained weights of early harvested Golden Delicious and Stayman were generally higher than those of later harvests (Table 3). With increased storage time of the raw fruit, drained weight of the canned slices tended to become higher. This was probably due to a drying of the tissue during storage which was recovered during the vacuum-blanch operation and from the liquid in the can.

Canned slices with no vacuum treatment had higher drained weights than slices submitted to vacuum, especially at higher blanch temperatures (Tables 3, 4). The highest blanch temperature gave slices with the highest drained weights. A weight pick-up of about 10–12% by canned fruit appeared to be normal. About half of this increase was accomplished during the vacuum-blanch process. As the percentage increase in drained weight over fill-in became higher than 15%, slices were more water-logged and soggy. The large pick-up in drained weight of non-vacuumized slices would seem to be due to the presence of air in the slices when they were canned. The syrup replaces the air in and around the fruit cells. In addition, as the air expands during further processing, considerable damage could be incurred by the cells, making them more susceptible to water uptake. In either case, soggy and waterlogged slices result. Slices given 1½ min vacuum followed by a blanch at 212°F gave a satisfactory drained weight pick-up without undue damage to the tissue. Longer vacuum periods seemed to increase drained weights and might have impaired filling of the slice after the vacuum operation.

There was a negative realtionship between shear press values of canned slices and drained weights, suggesting that softer slices, as a result of process, tend to absorb more moisture in the can (Table 2).

Canned slice firmness as measured by the shear press and estimated by panel were closely related (Table 2). In Golden Delicious canned slices, firmness decreased and color increased as more mature fruits were processed (compare Tables 5 and 6). In Stayman and York Imperial, canned slices of the second harvest were firmer and also higher in color acceptability than slices from the

Table 7.—Effect of harvest × storage interaction on shear (lb force) of canned Golden Delicious, Stayman, and York apple slices.

Harvest	Storage time—%		
	0	50	100
		Golden Delicious lb force	
1st	109	70	31
2nd	123	51	32
3rd	125	47	29
4th	111	43	29
L.S.D. 1% = 13			
		Stayman lb force	
1st	172	104	29
2nd	215	72	38
3rd	194	75	49
4th	174	58	45
L.S.D. 1% = 16			
		York Imperial lb force	
1st	218	141	87
2nd	218	204	144
3rd	156	159	112
4th	233	130	112
L.S.D. 1% = 21			

first harvest. Firmness and color decreased significantly as canned slices were made from fruit held in cold storage for increasing periods of time.

Slices not given a vacuum treatment were softer and lower in color acceptability than vacuum treated slices (Tables 5, 6). Golden Delicious and Stayman slices given at 3-min vacuum yielded the firmest canned samples while the longest vacuum treatments tended to give the best colored slices. Slices processed without blanching were lower in firmness than those receiving blanches of 212 and 225°F, but were similar to those receiving a 240°F blanch. Higher blanch temperatures were beneficial to the color of all varieties studied.

There was a significant harvest × storage interaction (Table 7) related to canned slice firmness. This was apparent because slices from second and third harvest fruit were firmer than slices from the first harvest if processed immediately, while most stored fruit gave softer slices with increasing maturity.

In the 3 varieties studied, the canned fruit of the blanched series had much more desirable flavor than unblanched fruit. Flavor was also improved in York Imperial slices by the higher blanch temperatures.

Sloughing became more prevalent as the blanch temperatures were increased. Large amounts of sloughing were observed in slices which had no vacuum treatment.

Fruit given no vacuum were graded lower in wholeness than slices given vacuum treatments while at 240°F-blanch impaired wholeness. Wholeness of slices generally decreased with longer storage and advanced maturity.

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